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Novel field test design for acquisition of DC and AC parameters during service

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Motivation

Being able to monitor early signs of PV module degradation, is needed to ensure stable power production throughout the service life of a PV installation. Impedance spectroscopy is proven to be a useful tool for detection of the presence and location of significant errors, and may have potential for more. In this work we describe a field test design where the modules are operating at their maximum power point, and via relays is switched out one by one for acquisition of an IV curve and an impedance spectrum. Some of the modules involved will undergo stimuli to accelerate certain degradation mechanisms, and fitting parameters extracted from the field test will be correlated with irradiance and compared to similar parameters of virgin modules of same kind, and conventional laboratory measurements on the same modules.

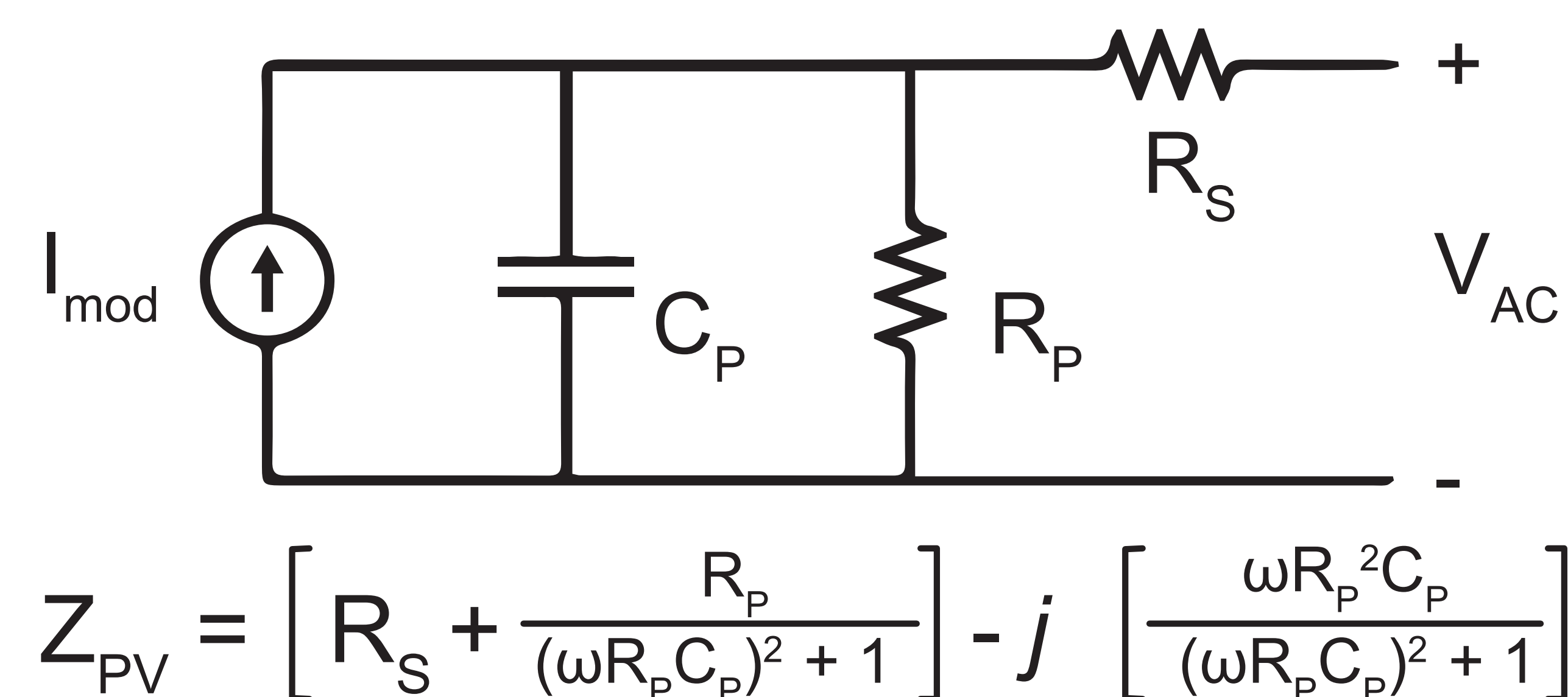


Fig.1 . Simplified AC-circuit of a PV-module and its resulting impedance.

Theory

Circuit parameters according to Fig 1. is fitted to the impedance spectras and their variation as a function of light and degradation will be investigated.



Fig. 2. Z100 Impedance measurement equipment - developed by EmaZys Technologies.

Measurement principle

The overall objective of this work is to establish a field test that enables to investigate how the faults on PV modules develop during normal operation. Of particular interest is to monitor and compare the impedance spectra with the IV-curves. The recorded panel data will then be correlated with irradiance data and module temperature data.

The modules will be connected to commercially available load electronics for grid connection. A relay system will be created which can switch the modules into a “measurement bus” facilitating a measurement of an IV-curve and acquisition of an impedance spectrum. The modules mounted on the field test will all be of the same kind and batch from the producer.

Some modules will be virgin, and some will be exposed to accelerated aging to stimulate specific degradation mechanisms.

The overall principle is shown in Fig. 3. and the load system is designed with the aim to maximize the time each module is operating in its maximum power point.

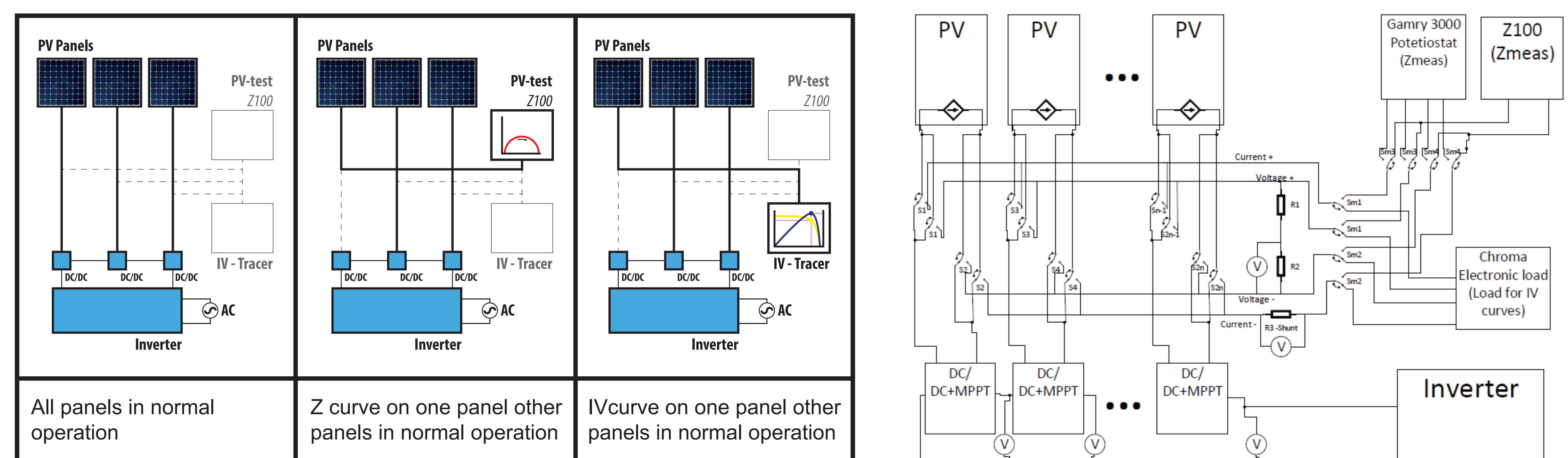


Fig. 3. Measurement principle illustrations

Experimental plan

The aim of the field test is to search for signs of early degradation of modules, of particular interest is:

- By pass diode failures
- Potential induced degradation (PID)
- Micro cracks
- Ribbon damage
- Delamination

Modules will be degraded targeting these mentioned failures and prior to any stimuli flash curves, impedance spectra and electroluminescence (EL) test are performed on the modules. The outdoor reference modules together with a selection of modules that has received degradation stimuli will be mounted on the field. Prior to mounting on the field test, flash tests, EL-test and laboratory impedance spectra's will be record as references.

The fitted values for the AC parameters being the parallel resistance, the series resistance and the parallel capacitance will be correlated with irradiation and temperature, and their development will be monitored and compared with flashing results and EL imaging. It is the expectation from the authors, that these experiments will guide the way for using impedance spectroscopy on installations to detect early signs of module degradation.